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1. Your reference — RFB/P60231

2. Patent application number *(The Patent Office will fill in this part)* — 30 SEP 1999 — **9923088.0**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

REFRIGERANT PRODUCTS LTD
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Patents ADP number *(if you know it)* — 7751795001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

REFRIGERANT

5. Name of your agent *(if you have one)* — URQUHART-DYKES + LORD

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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Patents ADP number *(if you know it)* — 16440~~27~~ 23

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Claim(s)

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Tel to R. Wilson
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Description = 21
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Request for preliminary examination and search *(Patents Form 9/77)*

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ROBIN F BROWNE
0113 245 2388

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REFRIGERANT

This invention relates to a refrigerant particularly but not exclusively for air conditioning systems. The system relates especially to refrigerant compositions which have no adverse effect on the atmospheric ozone layer and to compositions which can be added to existing refrigerants which are compatible with lubricants commonly used in refrigeration and air conditioning systems. The invention also relates to a method of modifying refrigeration and air conditioning systems.

Chlorofluorocarbons (CFCs) eg CFC 11 and CFC 12 are stable, of low toxicity and non-flammable providing low hazard working conditions used in refrigeration and air conditioning systems. When released they permeate into the stratosphere and attack the ozone layer which protects the environment from damaging effects of ultraviolet rays. The Montreal Protocol, an International environmental agreement signed by over 160 countries, mandates the phase-out of CFCs according to an agreed timetable. This now includes hydrochlorofluorocarbons (HCFCs) which also have an adverse effect on the ozone layer.
HCFC 22 is a chemical fluid and by far the largest HCFC refrigerant used globally in refrigeration and air conditioning equipment. HCFC 22 has an Ozone Depletion Potential (ODP) of approximately 5% of CFC 11. After CFCs have been phased out, the chlorine content of HCFC 22 will make it the largest ozone depleting substance in volumetric terms. HCFC 22 is also the subject of a phase-out schedule under the Montreal Protocol. HCFC 22 is prohibited from use in new equipment in some countries.

Any replacement for HCFC 22 must have no ability to deplete ozone. The compositions of the present invention do not include chlorine atoms and consequently they will have no deleterious effect on the ozone layer while providing a similar performance as a working fluid to HCFC 22 in refrigeration apparatus.

Various terms have been used in patent literature to describe refrigerant mixtures. These may be defined as follows:

Retrofit refrigerant mixture: A non-chlorine-containing mixture used to replace completely the original CFC or HCFC refrigerant.

Extender refrigerant mixture: A non-chlorine-containing mixture added during servicing to the CFC or HCFC refrigerant remaining in a unit, that is a top up refrigerant to make good any leakage or shortfall.

Hermetic compressor: A compressor where the electric motor is in the same totally welded casing as the compressor. The motor is cooled by the refrigerant vapour returning to the compressor. The heat generated by the motor is removed through the condenser.

Semi-hermetic compressor: Similar to a hermetic compressor, the major difference being the casing has a bolted joint which can be opened to enable the motor and compressor to be serviced.

Open compressor: A compressor which is driven by an external motor via a drive shaft passing through the compressor casing. The motor heat is dissipated directly to the environment, not via the condenser. This results in a slightly more efficient performance than a hermetic compressor, but refrigerant leaks can occur at the shaft seal.

Percentages and proportions referred to in this specification are by weight unless indicated otherwise. Percentages and proportions are selected to total 100%.

According to a first aspect of the present invention a refrigerant composition comprises a hydrofluorocarbon component comprising 1,1,1,2-tetrafluoroethane (HFC 134a) and an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range –5 to +70°C.

The hydrofluorocarbon component may be selected from the group consisting of HFC 134a, pentafluoroethane (HFC 125), difluoroethane (HFC 32) and mixtures thereof. A

preferred hydrofluorocarbon component comprises a mixture of HFC 125 and HFC 134a wherein the ratio of weights of HFC 125 to HFC 134a is in the range of 50 to 78:100. These compositions may be used as retrofit refrigerant mixtures. The composition may also be used as extenders as discussed below. The compositions may be used in semi-hermetic and hermetic systems.

The preferred ratio of HCFC 125 to HCFC 134a is 54 to 78:100, preferably 60 to 78:100, more preferably 64 to 76:100. These ranges find particular application in hermetic and semi-hermetic systems. The preferred ratio in an open system is 57 to 78:100 more preferably 63 to 76:100. The proportion of HCFC 125 used in an open system may be up to 10%, preferably about 4-5% higher than in a hermetic or semi-hermetic system in order to achieve a required refrigeration capacity.

The hydrocarbon additive preferably has a boiling point in the range – 5 to +50°C more preferably 20 to 50°C. Higher boiling ranges find particular application in automobile air conditioning units. Preferred hydrocarbons additives are selected from the group consisting of: 2-methylpropane, 2,2-dimethylpropane, n-butane, n-pentane, 2-methylbutane, cyclopentane, hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethybutane and methylcyclopentane. It is especially preferred to use n-pentane, cyclopentane or a commercially available pentane or other saturated hydrocarbon mixture boiling in the range 20 to 50°C. Commercially available saturated hydrocarbon mixtures are available from cyclopentane commercial grade from Phillips Petroleum International NV, Norpar P5 S n-pentane from Exxon Chemical and iso-pentane Q1111 from Shell Chemicals.

The amount of hydrocarbon additive may be up to 10%, preferably 1 to 8 % and more preferably about 2 to 4%.

According to a second aspect of the present invention a refrigerant extender mixture comprises a composition in accordance with the first aspect of this invention.

According to a third aspect of this invention a refrigerant composition comprises a composition in accordance with the first aspect of this invention together with HCFC 22. This invention also provides a method of modifying a refrigerator or air conditioning system incorporating HCFC 22 as refrigerant, the method comprising the step of adding a composition in accordance with the second aspect of this invention to the refrigerant of the system.

Positive displacement compressors, that is reciprocating or rotary compressors, used in refrigeration systems suck in small amounts of lubricant from the crank case which are ejected with the refrigerant vapour through the exhaust valves. In order to maintain compressor lubrication this oil must be forced around the circuit by the refrigerant stream and returned to the crank case. CFC and HCFC refrigerants are miscible with hydrocarbon oils and hence carry the oils around the circuit. However HFC refrigerants and hydrocarbon lubricants have low mutual solubilities so effective oil return may not occur. The problem is particularly acute in evaporators where low temperatures can increase the viscosities of oils sufficiently to prevent them being carried along the tube walls. With CFCs and HCFCs enough refrigerant remains in the oil to reduce the viscosities to enable oil return to occur.

When using HFCs with hydrocarbon lubricants oil return can be facilitated by introducing into the system a hydrocarbon fluid having the following properties:

(a) sufficient solubility in the lubricant at the evaporator temperature to reduce its viscosity; and

(b) sufficient volatility to allow distillation from the hot lubricant in the compressor crank case.

Hydrocarbons as defined above fulfil these requirements.

Refrigerant compositions in accordance with this invention confer several advantages. The presence of HFC 125 suppressess the flammability of the refrigerant mixture. HFC

125 has fire suppressing characteristics. The higher HFC content enables more pentane or other hydrocarbon to be added to the mixture thereby reducing the viscosity of the traditional lubricants, for example mineral and alkyl benzene oils.

The present invention may confer a number of benefits in comparison to HCFC 22 including; lower discharge temperature, lower discharge pressure in certain systems, lower combustibility and improved cooling of the motor in a refrigeration apparatus and lower pressure differential across the compressor. The boiling point of HFC 125 is higher than either HFC 32 or a combination of HFC 125 and HCFC 32. This may allow the refrigerant of this invention to have a lower glide than some replacements for HFC 22 which contain HCFC 32. The higher content of HFC 125 increases the capacity of the invention compared to some other replacements for HCFC 22.

The invention is further described by means of examples but not in any limitative sense.

Example 1

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in hermetic or semi-hermetic systems. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight. 56% by weight 134a

2. A composition comprising 56% R125 by weight, 44% by weight 134a

3. A composition comprising 64% R125 by weight, 36% by weight 134a

4. A composition comprising 76% R125 by weight, 24% by weight 134a

5. A composition comprising 80% R125 by weight, 20% by weight 134a

The following cycle conditions were used in the analysis:

COOLING DUTY DELIVERED	10 kW
EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficienct	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 1. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because it exhaust pressure is more than 2 bar above that of R22. Composition 1 is unacceptable because the refrigerant

capacity is less than 90% of that of R22. The overall performances of compositions 2, 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention

Example 2

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in open systems. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air-conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight, 56% by weight 134a
2. A composition comprising 56% R125 by weight, 44% by weight 134a
3. A composition comprising 64% R125 by weight, 36% by weight 134a
4. A composition comprising 76% R125 by weight. 24% by weight 134a
5. A composition comprising 80% R125 by weight, 20% by weight 134a

The following cycle conditions were used in the analysis:

COOLING DUTY 10 kW

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 2. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because its exhaust pressure is more than 2 bar above that of R22. Compositions 1 and 2 are unacceptable because their refrigerant capacities are less than 90% of that of R22. The overall performances of

compositions 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention.

Example 3

The performances of five R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as retrofit replacements for R22 in hermetic or semi-hermetic systems not fitted with a liquid line/suction line heat exchanger. The operating conditions, used for the analyses were chosen as being typical of those conditions that are found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following refrigerant compositions were subjected to cycle analysis:

1. A composition comprising 44% R125 by weight, 56% by weight 134a
2. A composition comprising 56% R125 by weight, 44% by weight 134a
3. A composition comprising 64% R125 by weight, 36% by weight 134a
4. A composition comprising 76% R125 by weight, 24% by weight 134a
5. A composition comprising 80% R125 by weight, 20% by weight 134a

The following cycle conditions were used in the analysis:

COOLING DUTY 10 kW

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperate	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.47 kW
Outdoor fan	0.26 kW
Controls	0.1 kW

The results from analysing the performances in an air-conditioning unit using these operating conditions are shown in Table 3. For comparison the performance of R22 is also shown.

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account. However composition 5 is unacceptable because its exhaust pressure is more than 2 bar above that of R22. Compositions 1 and 2 are unacceptable because their refrigerant capacities are less than 90% of that of R22. The overall performances of compositions 3 and 4 meet the criteria set out above and therefore satisfy the requirements of this invention.

Example 4

The performances of two R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program in order to assess their suitability as extenders for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analyses are typical of those conditions found in air conditioning systems. Since the blends were zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle and were also used to generate the performance of R22 for comparison.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender compositions were subjected to cycle analysis:

1. A composition comprising 64% R125 by weight, 36% by weight 134a.

2. A composition comprising 44% R125 by weight, 56% by weight 134a.

To establish the effects on unit performance resulting from successive dilutions of R22 by the above extenders the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are summarised in Tables 4a and 4b. Key parameters are plotted in Chart 1 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

COOLING DUTY 10 kW

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

All compositions have lower exhaust temperatures than R22 and are therefore superior on this account.

Composition 1 provides a cooling capacity greater than 90% of that of R22 over the whole of the dilution range. Blends containing more than 45% R22 have capacities equal to or better than that of R22. The COP (system) is within 2% of that of R22 over the whole of the dilution range. This composition therefore meets the requirements of this invention.

Composition 2 provides a cooling capacity greater than that 90% of R22 for blends containing down to 20% of R22. Its COP (system) is essentially the same as that of R22

over the whole of the dilution range. This composition therefore meets the requirements of this invention for blends containing down to 20% R22.

Example 5

An R32/R134a/pentane composition was evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess its suitability as an extender for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in air conditioning systems. Since the blend was a zeotrope the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R32/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender composition was subjected to cycle analysis:
A composition comprising 44% R125 by weight, 56% by weight 134a.

To establish the effect on unit performance resulting from successive dilutions of R22 by topping up with the above extender the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are shown in Table 5 and the results plotted out in Chart 2 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

EVAPORATOR

Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C

Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Controls	0.1 kW

All blends containing the extender have lower exhaust temperatures than R22 and therefore meet the requirements of this specification. The COP (system) is essentially equal to that of R22 over the whole of the dilution range. The cooling capacity of the refrigerant is not less than 98% of that of R22 over the whole of the dilution range. For dilutions down to 20% of R22 the capacity is equal to or greater than that of R22. The exhaust pressure is less than the 0.5 bar above that of R22 over the whole of the dilution range.

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 5.

R32/134a 30/70 therefore meets the requirements of this invention.

Example 6

An R32/R125/R134a/pentane composition was evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess its suitability as an extender for R22 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in air conditioning systems. Since the blend was a zeotrope the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R22.

The pentane was present at 4% by weight based on the total weight of the R32/R134a blend.

This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

The following R22 extender composition was subjected to cycle analysis:

A composition comprising 23% by weight of 32, 25%R125 by weight and 52% by weight 134a.

To establish the effect on unit performance resulting from successive dilutions of R22 by topping up with the above extender the cycle was analysed for refrigerant compositions containing mass fractions of R22 from 1.0 down to 0.0. The results are shown in Table 6 and the results plotted out in Chart 3 with the calculated points connected by smooth curves.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
LIQUID LINE/SUCTION LINE HEAT EXCHANGER	
Efficiency	0.3
COMPRESSOR	
Electric motor efficiency	0.8
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82
PARASITIC POWER	
Indoor fan	0.3
Outdoor fan	0.4 kW
Controls	0.1 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 6.

All blends containing the extender have lower exhaust temperatures than R22 and therefore meet the requirements of this specification. The COP (system) is not less than 98% of that of R22 over the whole of the dilution range. The cooling capacity of the refrigerant is greater than of that of R22 over the whole of the dilution range. The exhaust pressure is less than the 2.0 bar above that of R22 over the whole of the dilution range.

R32/134a 30/70 therefore meets the requirements of this invention.

Example 7

R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess their suitabilities as retrofits for R12 in hermetic or semi-hermetic systems. The operating conditions selected for the analysis are typical of those conditions found in refrigeration systems. Since the blends were, strictly speaking, zeotropes the midpoints of their temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R12.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

Compositions containing 1 and 15% R125 were considered.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	45.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C

LIQUID LINE/SUCTION LINE HEAT EXCHANGER

Efficiency	0.3

COMPRESSOR

Electric motor efficiency	0.85
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Indoor fan	0.3 kW
Outdoor fan	0.4 kW
Control	0.1 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 7 and key parameters plotted in Chart 4.

All blends have lower exhaust temperatures than R12 and therefore meet the requirements of this specification on this account.

The COPs (system) are not less than 97% of that of R12. The cooling capacities of all the compositions are greater than 90% of that of R12 over the whole of the dilution range.

Compositions containing 3% or more R125 have capacities greater than 95% of that of R12. Compositions containing 12 % or more of R125 have capacities greater than that of R12.

The discharge pressures do not exceed that of R12 by more than 2 bar for all compositions.

All compositions meet the requirements of this invention. Compositions with 9 to 13 % R125 are especially promising, providing a good compromise between discharge pressure and capacity.

Example 8

R125/R134a/pentane compositions were evaluated using standard refrigeration cycle analysis techniques provided by the NIST 'CYCLE D' program to assess their suitabilities as retrofits for R12 in mobile air conditioning systems systems. The operating conditions selected for the analysis are typical of those conditions found in MAC systems. Since the blends were, strictly speaking, zeotropes the midpoints of its temperature glides in the evaporator and condenser were chosen to define the temperature limits of the cycle. The same temperatures were also used to generate performance data for R12.

The pentane was present at 4% by weight based on the total weight of the R125/R134a blend. This amount was considered insufficient to affect significantly the cycle performance of the refrigerant so was not included in the calculation.

Compositions containing 1 and 17% R125 were considered.

The following cycle conditions were used in the analysis:

EVAPORATOR	
Midpoint fluid evaporation temperature	7.0 °C
Superheating	5.0 °C
Suction line pressure drop (in saturated temperature)	1.5 °C
CONDENSER	
Midpoint fluid condensing temperature	60.0 °C
Subcooling	5.0 °C
Exhaust line pressure drop (in saturated temperature)	1.5 °C
COMPRESSOR	
Compressor isentropic efficiency	0.7
Compressor volumetric efficiency	0.82

PARASITIC POWER

Condenser fan 0.4 kW

The results of analysing the performance of an air-conditioning unit using these operating conditions are shown in Table 7 and key parameters plotted in Chart 5.

All blends have lower exhaust temperatures than R12 and therefore meet the requirements of this specification on this account.

The cooling capacities of all the compositions are greater than of that of R12 over the whole of the range.

Compositions containing up to 3% of R125 have discharge pressures that do not exceed that of R12 by more than 2 bar.

For high capacities in equipment that can withstand higher pressures 5 to 17% R125 is preferred and especially preferred is 10 to 17%.

If maximum pressure is a concern then blends containing 0 to 3 % 125 are preferred which boost capacity but do not exceed the pressure of R12 by more than 2 bar. These blends are near-azeotropic.

CLAIMS

1. A refrigerant composition comprising a hydrofluorocarbon component including 1,1.1.2-tetrafluoroethane (HFC 134a), the composition further comprising an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range –5 to +70°C.

2. A refrigerant composition as claimed in claim 1, wherein the hydrofluorocarbon component is selected from the group consisting of HFC 134a, pentafluoroethane (HFC 125), difluoroethane (HFC 32) and mixtures thereof.

3. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 125 and HFC 134a wherein the ratio of weights of HFC 125 to HFC 134a is in the range of 50 to 78:100.

4. A refrigerant composition as claimed in claim 3, wherein the ratio is 50 to 78:100.

5. A refrigerant composition as claimed in claim 4, wherein the ratio is 60 to 78:100.

6. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 125 and HFC 134a wherein the ratio of weights of HFC 125 to HFC 134a is in the range 1 to 15:100.

7. A refrigerant composition as claimed in claim 2, wherein the HFC component comprises HFC 32 and HFC 134a wherein the ratio of weights of HFC 32 to HFC 134a is in the ratio of 25 to 35:100.

8. A refrigerant composition as claimed in claim 5, wherein the hydrocarbon additive has a boiling point in the range of 20 to 50°C.

9. A refrigerant composition as claimed in claims 5 or 6, wherein the hydrocarbon additive is selected from the group consisting of 2-methylpropane, 2,2-dimethylpropane, n-butane, n-pentane, 2-methylbutane, cyclopentane, hexane, 2-methylpentane, 3-methylpentane. 2.2-dimethybutane and methylcyclopentane.

10. A refrigerant composition as claimed in claim 5, wherein the hydrocarbon additive is selected from n-pentane, iso-pentane, cyclopentane or mixtures thereof.

11. A refrigerant composition as claimed in any preceding claim, wherein the amount of hydrocarbon additive is trace to 10%.

12. A refrigerant composition as claimed in claim 9. wherein the amount of hydrocarbon additive is 1 to 8%.

13. A refrigerant composition as claimed in claim 10, wherein the amount of hydrocarbon additive is 2 to 4%.

14. A refrigerant extender mixture comprising a refrigerant composition as claimed in any preceding claim.

15. A refrigerant composition as claimed in any of claims 1 to 11 together with a proportion of HCFC 22.

16. A method of modifying a refrigerator or air conditioning system which incorporates HCFC 22 as refrigerant, the method comprising the step of adding a refrigerant extender as claimed in claim 12 to the refrigerant of the system.

17. Use of a refrigerant composition as an extruder to HCFC 22, wherein the HFC component comprises HFC 32, HFC 125 and HFC 134a wherein the ratio of weights of HFC 32, HFC 125 and HFC 134a is in the range 18 to 28, 20 to 30 and 42 to 62:100.

ABSTRACT

REFRIGERANT

A refrigerant composition comprising a hydrofluorocarbon component including 1,1,1,2-tetrafluoroethane (HFC 134a), the composition further comprising an additive selected from a saturated hydrocarbon or mixture thereof boiling in the range –5 to +70°C.

Table 1

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	104.68	79.75	78.51	77.60	76.07	75.51
COP (system)	2.49	2.50	2.47	2.45	2.41	2.40
Capacity (kW/m^3)	3066	2581	2747	2862	3041	3102
Glide in evaporator (°C)	0	3.06	3.17	3.03	2.47	2.19
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 2

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	92.9	72.8	71.9	71.2	70.1	69.7
COP (system)	2.59	2.57	2.54	2.52	2.48	2.47
Capacity (kW/m^3)	3222	2669	2838	2956	3138	3200
Glide in evaporator (°C)	0	3.06	3.17	3.03	2.47	2.19
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 3

Refrigerant % by weight	R-22	1. 125/134a 44/56	2. 125/134a 56/44	3. 125/134a 64/36	4. 125/134a 76/24	5. 125/134a 80/20
Discharge pressure (bar)	17.91	15.89	17.19	18.13	19.68	20.23
Discharge temperature (°C)	94.63	71.81	70.63	69.71	68.082	67.47
COP (system)	2.45	2.42	2.39	2.37	2.33	2.36
Capacity (kW/m^3)	3077	2535	2692	2800	2965	3021
Glide in evaporator (°C)	0	2.88	2.99	2.87	2.34	2.07
Glide in condenser (°C)	0	2.97	2.94	2.71	2.09	1.81

Table 4a R125/R134a 64%/36% as Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	18.13	18.47	18.69	18.81	18.84	18.80	18.70	18.56	18.37	18.15	17.91
Discharge temperature (°C)	77.6	79.7	81.8	84.0	86.4	89.0	91.7	94.6	97.8	101.1	[illegible]
COP (system)	2.45	2.45	2.46	2.46	2.47	2.47	2.48	2.48	2.49	2.49	2.49
Capacity (kW/m^3)	2862	2937	2996	3042	3074	3096	3107	3108	3101	3087	3069
Glide in evaporator (°C)	3.03	2.91	2.66	2.36	2.04	1.73	1.41	1.08	0.75	0.39	0
Glide in condenser (°C)	2.71	2.55	2.31	2.06	1.80	1.54	1.28	1.09	0.71	0.38	0

Table 4b R125/R134a 44%/56% as Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	15.90	16.41	16.83	17.17	17.44	17.64	17.79	17.88	17.93	17.93	17.91
Discharge temperature (°C)	79.6	81.7	83.7	85.8	88.0	90.3	92.8	95.5	98.3	101.4	104.7
COP (system)	2.50	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49
Capacity (kW/m^3)	2581	2675	2756	2825	2885	2935	2977	3010	3036	3054	3066
Glide in evaporator (°C)	3.06	3.08	2.91	2.62	2.27	1.89	1.50	1.12	0.74	0.37	0
Glide in condenser (°C)	2.97	2.89	2.66	2.36	2.02	1.69	1.34	1.00	0.67	0.34	0

Table 5 R32/134a 30/70 as an Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	18.08	18.18	18.27	18.33	18.36	18.36	18.34	18.28	18.19	18.07	17.91
Discharge temperature (°C)	98.0	98.4	98.9	99.3	99.8	100.4	101.0	101.8	102.6	103.6	104.7
COP (system)	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49
Capacity (kW/m^3)	3030	3049	3066	3080	3091	3098	3101	3100	3094	3083	3066
Glide in evaporator (°C)	5.03	4.59	4.12	3.62	3.11	2.59	2.07	1.55	1.03	0.51	0
Glide in condenser (°C)	5.13	4.62	4.11	3.60	3.08	2.57	2.07	1.56	1.06	0.54	0

Table 6 R32/125/134a 23/25/52 as an Extender for R22

Refrigerant % R22 by weight	0	10	20	30	40	50	60	70	80	90	100
Discharge pressure (bar)	19.30	19.32	19.30	19.25	19.16	19.03	18.87	18.68	18.45	18.20	17.91
Discharge temperature (°C)	92.5	93.3	94.1	95.0	96.0	97.1	98.4	99.7	101.2	102.9	104.7
COP (system)	2.47	2.47	2.47	2.47	2.47	2.48	2.48	2.48	2.49	2.49	2.49
Capacity (kW/m^3)	3172	3183	3190	3193	3191	3183	3171	3157	3129	3101	3066
Glide in evaporator (°C)	4.8	4.4	3.9	3.4	2.9	2.4	1.9	1.5	1.0	0.5	0
Glide in condenser (°C)	4.7	4.2	3.8	3.3	2.8	2.4	1.9	1.5	1.0	0.5	0

Table 7 R125/134a as an R12 Retrofit

Refrigerant % R125 by weight	R12	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discharge pressure (bar)	11.21	12.05	12.13	12.20	12.28	12.36	12.44	12.51	12.59	12.67	12.75	12.83	12.91	12.99	13.07	13.15	13.24
Discharge temperature (°C)	127.6	118.2	118.0	117.9	117.7	117.5	117.4	117.2	117.1	116.9	116.8	116.6	116.4	116.2	116.1	115.9	115.8
COP (system)	1.36	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Capacity (kW/m^3)	698.2	652.7	656.5	660.3	664.2	668.0	671.9	675.9	679.8	683.8	687.8	691.9	695.9	700.0	704.1	708.3	712.4
Glide in evaporator (°C)	0	0	0.08	0.18	0.26	0.35	0.44	0.52	0.61	0.69	0.77	0.85	0.93	1.01	1.09	1.17	1.25
Glide in condenser (°C)	0	0	0.12	0.24	0.35	0.47	0.58	0.69	0.80	0.90	1.00	1.10	1.20	1.30	1.39	1.48	1.56

Table 8 R125/134a as an MAC R12 Retrofit

Refrigerant % R125 by weight	R12	0	1	3	5	7	9	11	13	15	17
Discharge pressure (bar)	15.72	17.42	1752	17.72	17.93	18.14	18.36	18.57	18.79	19.01	19.24
Discharge temperature (°C)	88.4	84.4	84.4	84.3	84.3	84.3	84.2	84.2	84.1	84.1	84.0
COP (system)	2.45	2.38	2.37	2.34	2.36	2.36	2.35	2.34	2.34	2.33	2.32
Capacity (kW/m^3)	1754	1771	1779	1794	1809	1824	1840	1856	1871	1887	1902
Glide in evaporator (°C)	0	0	.08	0.22	0.37	0.51	0.65	0.78	0.91	1.00	1.16
Glide in condenser (°C)	0	0	0.10	0.30	0.50	0.68	0.85	1.02	1.17	1.32	1.46

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Figure 1: R125/134a 64/36 and 44/56 as R22 Extenders

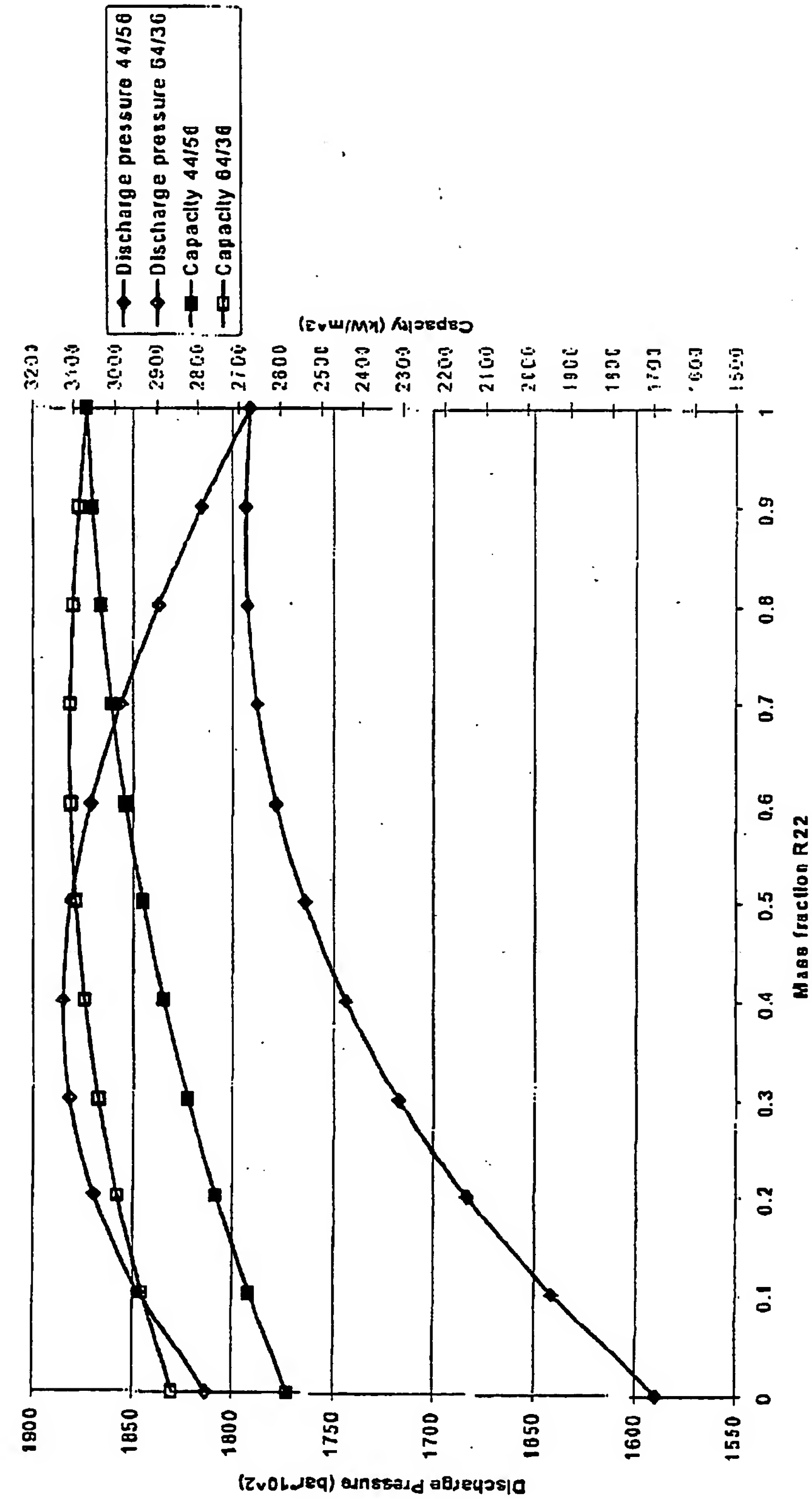

Figure 2: R32(30)/R134a(70) as an extender for R22

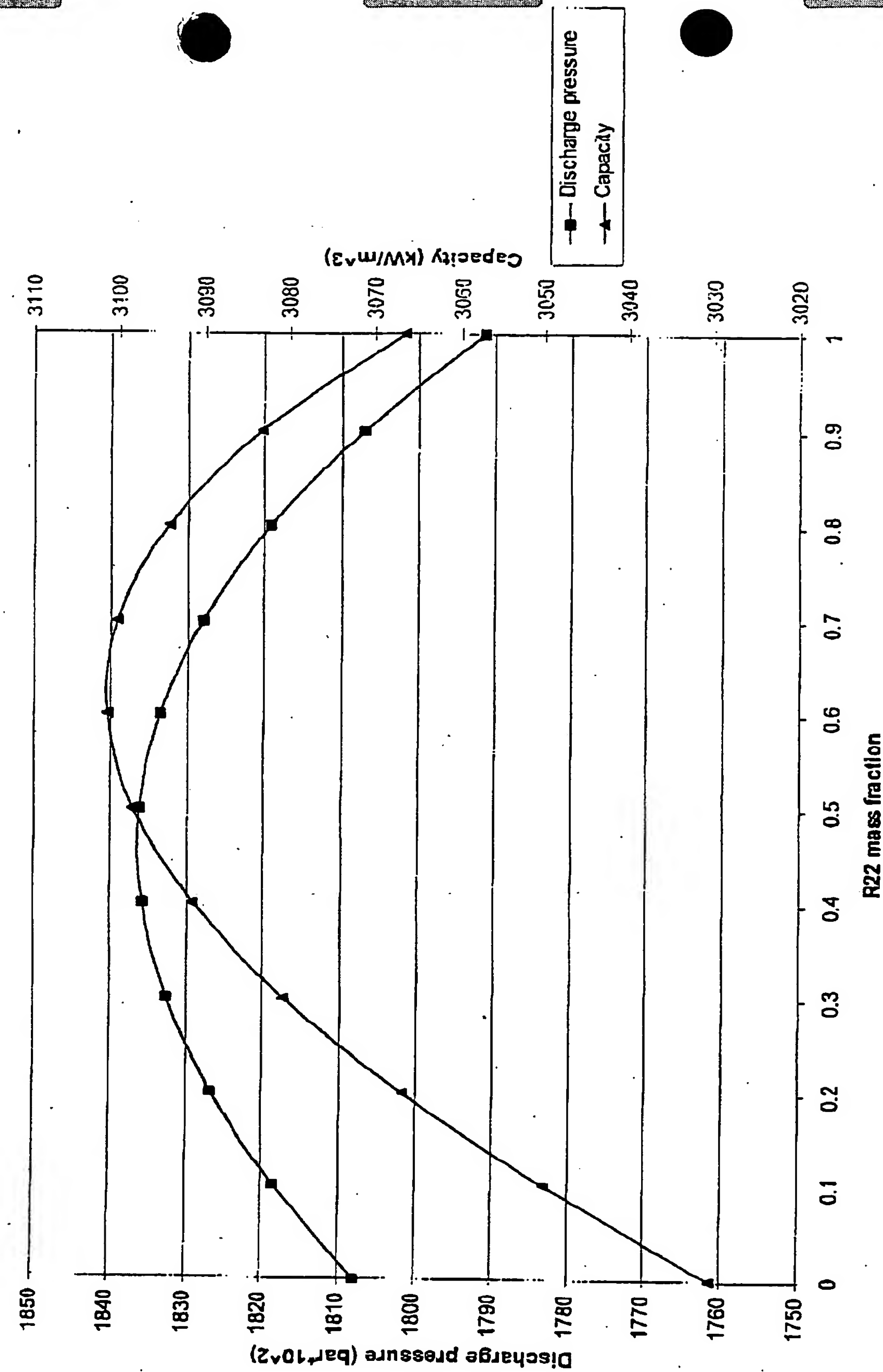

Figure 3: 32/125/134a 23/25/52 as an extender for R22

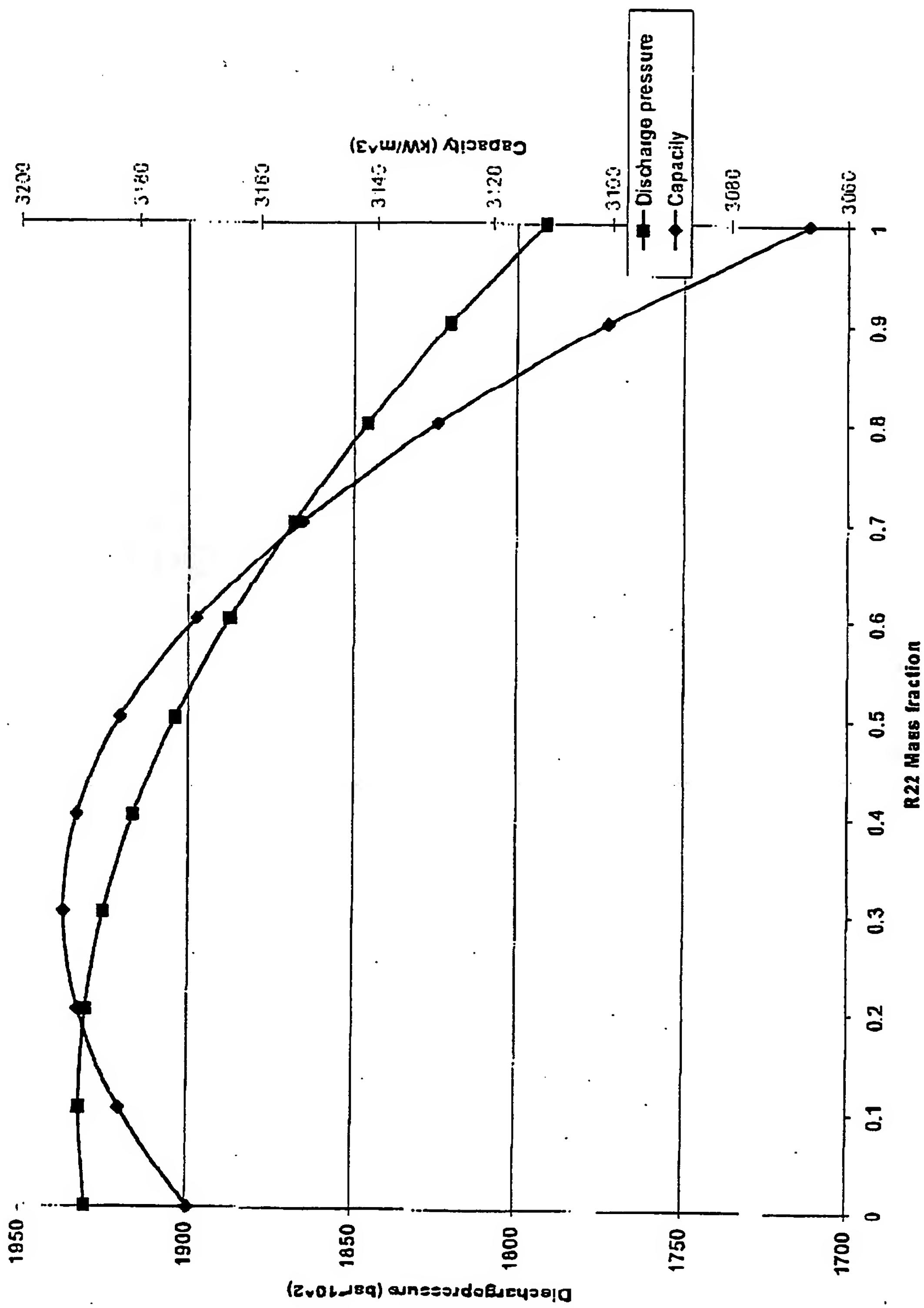

Figure 4: R134a + R125 as an R12 Retrofit

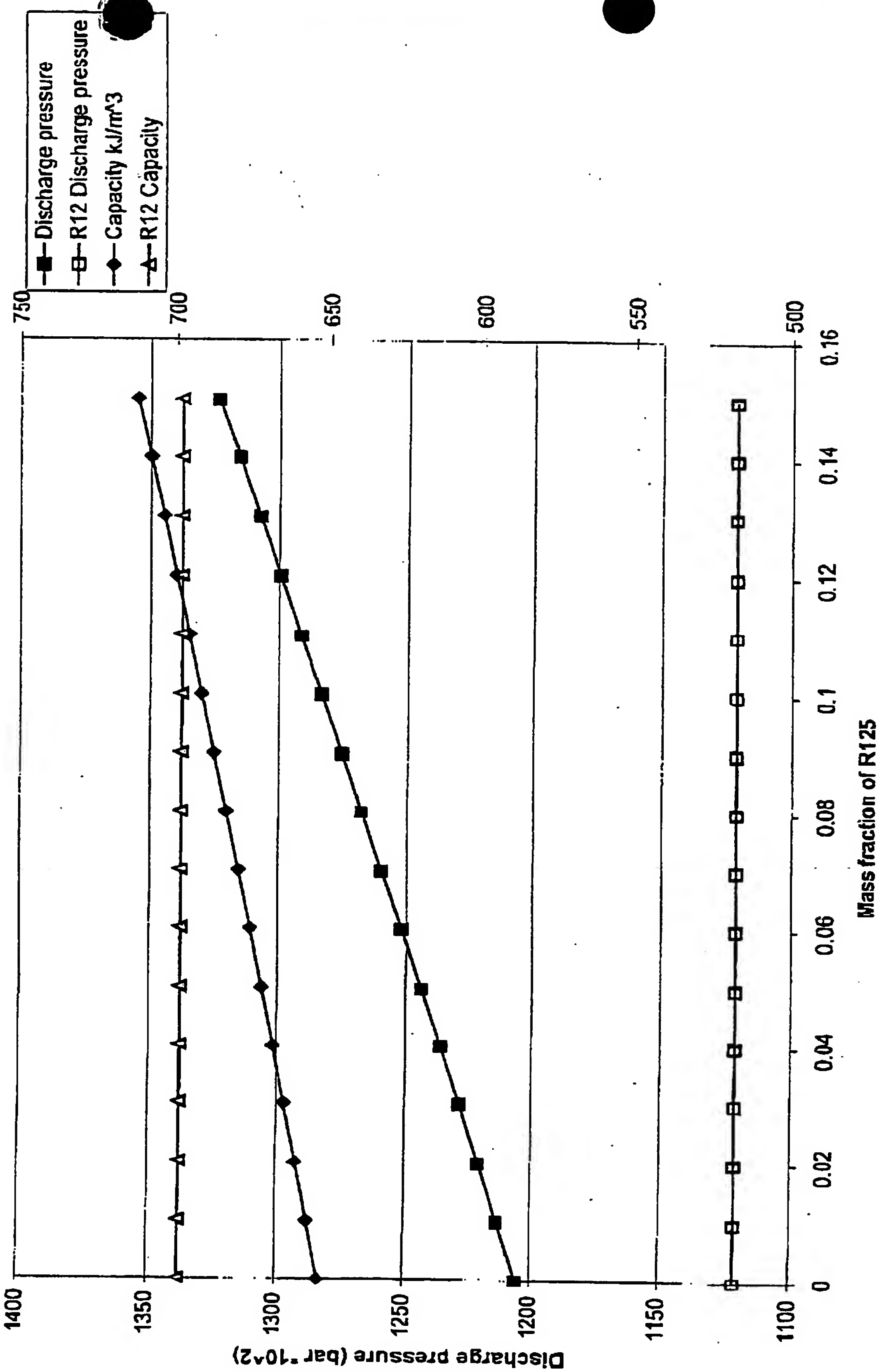

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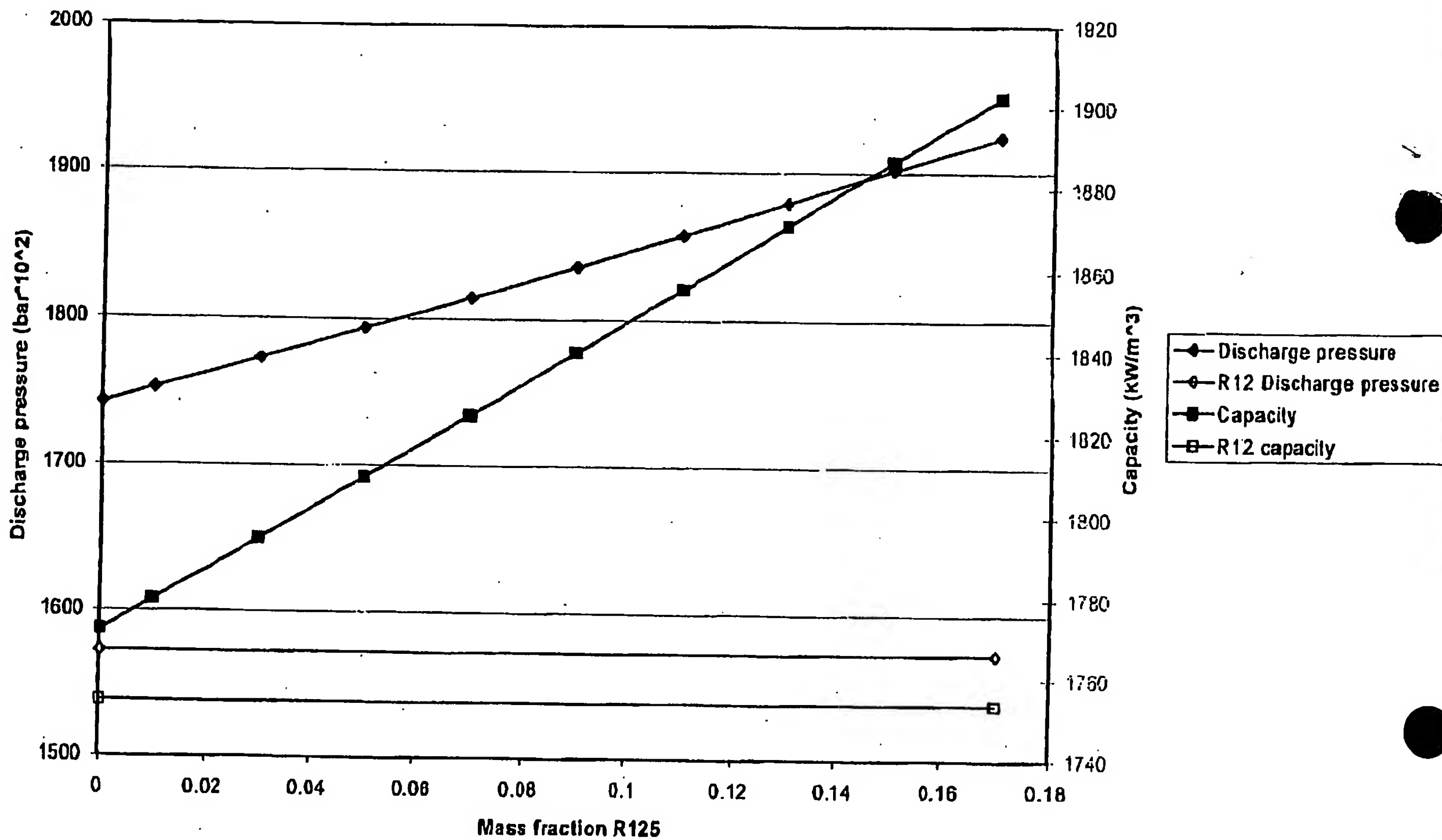
Figure 5: R134a + R125 as an MAC R12 Retrofit



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